# PATH 15 UPGRADE PROJECT

# NORTH-TO-SOUTH RATING STUDY

**WECC Rating Process**

**Phase 1**

**Comprehensive Progress Report**

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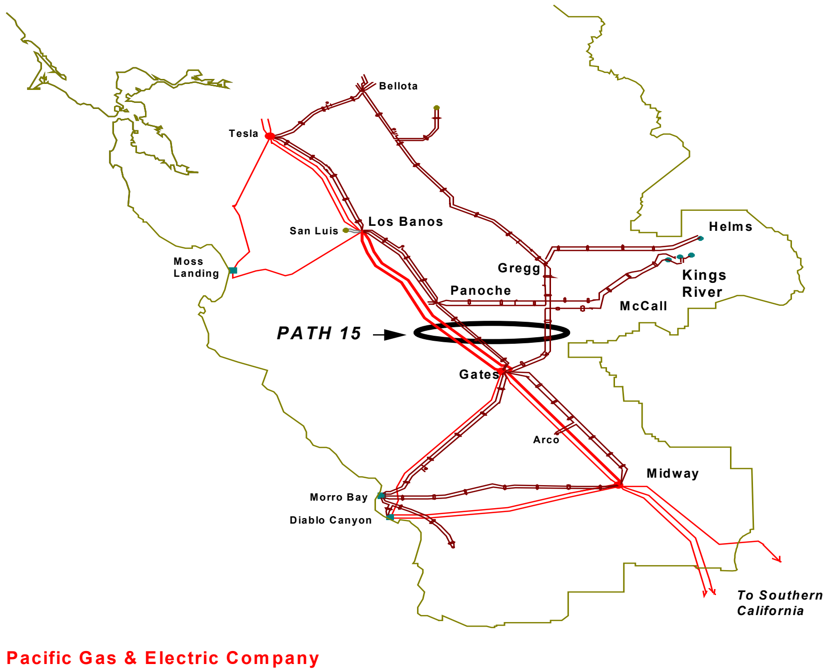
August 5, 2002

## 1. INTRODUCTION

Path 15 is located in the southern portion of the PG&E service area in the center of the California ISO-controlled grid as illustrated in Figure 1:

Figure 1




It consists of the following lines:

| | |
|---|---|
| Los Banos-Gates 500 kV | Gates-Panoche #2 230 kV |
| Los Banos-Midway 500 kV | Gates-Gregg 230 kV |
| Gates-Panoche #1 230 kV | Gates-Mc Call 230 kV |

A Path 15 Upgrade is currently being considered to increase its south-to-north transfer capability. This capability is limited because the possibility of a simultaneous outage of the two existing 500 kV lines must be considered in accordance with the WECC Reliability Criteria.

The Path 15 upgrade will provide Northern California with better access to the existing and proposed resources in the Midway area, Southern California and the Southwest.

The corresponding service plan increases south-to-north transfer capability by about 1500 MW to 5400 MW and includes the following facilities:

1. Construct an uncompensated, single circuit 500 kV line between Los Banos and Gates substations.
2. Install 225 MVAr shunt capacitors at the Los Banos and Gates 230 kV buses.
3. Establish a second 230 kV transmission circuit between Gates and Midway substations.
4. Modify the remedial actions taken for double line outages between Tesla and Midway

An increase of Path 15 north-to-south transfer capability may be also desirable and the parties involved in the implementation of the upgrade requested that PG&E study this matter.

Conditions for intensive north-to-south flow on Path 15 may occur in some periods of the spring and summer with partial peak Northern California load and a surplus of hydro generation resources in the Northwest and Northern California. During such periods, the Path 15 capability may not be sufficient to transfer the surplus to Southern California. In addition, Path 26, which has an existing north-to-south transfer capability of 3000 MW, may not be sufficient to support such transfers. The latter limitation may become even more evident with the addition of about 2000 MW of mew generation in Midway area.

Alternatives to increase the Path 26 rating to 4000 MW are being considered in ongoing studies. One such alternative involves the execution of remedial actions for double outages of the Midway-Vincent 500 kV lines.

This north-to-south Path 15 study includes the power flow and stability analysis for Los Banos-Midway double line outages, Pacific DC Intertie bipole outage, and a Palo Verde double unit outage based on Path 26 ratings of 3000 MW (existing) and 4000 MW (proposed). This study does not consider the Midway-Vincent double line outage and thus does not attempt to justify whether a Path 26 rating increase complies with the reliability criteria.

## 2. BASE CASES

The foundation of all base cases, considered in this study, is the 2003 Heavy Summer WECC approved case (03HS3-S). The main parameters of this case are given in Table 2-1. The same Table presents three cases, derived from 03HS3-S. Two of those cases (with 3000 MW and 4000 MW on Path 26) are benchmark cases for the pre-project conditions and one case (for 4000 MW on Path 26) is a benchmark case for the post-project conditions. Characteristics of additional cases (for example, one DCPP unit off-line) that were constructed in the search for Path 15 limits, are provided in Tables 4-1 – 4-3.

**Table 2-1**

| | **Pre-project** | | | **Post-project** | **Pre-project** |
|---|---|---|---|---|---|
| | **03HS3-S** | **P26 rating =3000 MW** | **P26 rating =4000 MW** | **P26 rating =4000 MW** | **03HSP1-OP** |
| Path 15 (n – s) | -1365 | 1555 | 1750 | 2150 | 1270 |
| COI (n – s) | 3420 | 4280 | 4260 | 4260 | 4800 |
| PDCI (n –s)–sending end | 2200 | 2980 | 2980 | 2980 | |
| Path 26 (n – s) | 2185 | 2955 | 3985 | 3980 | 2820 |
| Borah West (e – w) | 940 | 725 | 670 | 645 | |
| Mid-zone Generation[1] | | | | | |
| DCPP | 2270 | 2200 | 2270 | 2270 | 2240 |
| Morro Bay+Sunset+ + new Midway Pwr. Plants[2] | 2700 | 925 | 1480 | 1000 | 100 |
| PG&E area load (without losses) | 25325 | 22980 | 22980 | 22460 | 15620 |
| N. California Hydro-generation | 3630 (90%) | 3630 (90%) | 3630 (90%) | 3630 (90%) | 2850 (70%) |

The 03HS3-S case features significant PG&E area load of over 25000 MW, which is supplied in part by 3420 MW from COI (COI can be increased by l 100 MW and remain within its capability) and full utilization of DCPP and new power plants in the Midway area. Such a schedule creates conditions, which are far from critical for north-to-south studies of Path 15. In fact, Path 15 flow is 1365 MW from south to north and Path 26 flow is just 2185 Mw from north to south

[1] Generation sited between Path 15 and Path 26 in the CAISO-controlled grid (some mid-zone power plants were not varied in this study, their generation is not included in the above total).
[2] New Midway Power Plants are La Paloma, Elk Hills and Sunrise.

The desirable features of the three benchmark cases are derived by the following changes in the 03HS3-S case:

1) generation increase in Northwest (this increase was limited by the residual capacities of COI and PDCI);
2) generation increase and load reduction in the NP 15 zone (in addition to adjustment 1 to provide desirable loading of Path 15);
3) generation decrease in the Midway area (to limit Path 26 flow to its 3000 MW or 4000 MW rating , if greater flow is produced by adjustments 1 and 2);
4) load increase in Arizona and Southern California (to balance adjustments 1,2 and 3);
5) PDCI flow rescheduling from 2200 to 2980 MW.

These adjustments can be viewed as quite plausible considering a wide spectrum of summer and spring conditions. As mentioned above, this is particularly true for spring conditions with moderate PG&E load, when surplus low-cost hydro resources in Northwest and Northern California would result in reduced dispatch of many generators in California, including new generators in the ZP26 area. Such conditions may produce significant north-to-south flow on Path 15 while keeping Path 26 flow within its rating as illustrated by the 03HSP1-OP spring case (see Table 2-1). This case was recently compiled for the PG&E part of the system but as of June 2003, was not compiled for the whole WECC system.

## 3. STUDY SCOPE AND CRITERIA

Full-scale post-transient and transient analyses were conducted to find Path 15 flow that would satisfy the CAISO planning criteria, which include the WECC planning criteria. These planning criteria are summarized below:

| | Overloads | Transient Voltage Dip | Transient frequency | Post-Transient Voltage Dip | Real Power Margin (%) | Reactive Power Margin (MVAr) |
|---|---|---|---|---|---|---|
| Single Outages | Emergency Rating | ≤ 25%<br>> 20% voltage for ≤ 20 cycles | <6 cycles below 59.6 Hz | ≤ 5% | 5 | 500 kV: 500<br>230 kV: 150-200 |
| Double Outages | Emergency Rating | ≤ 30%<br>> 20% voltage for ≤ 40 cycles | <6 cycles below 59.0 Hz | ≤ 10% | 2.5 | 500 kV: 250<br>230 kV: 150-200 |

The earlier studies have shown that single line 500 kV outages in the Path 15 area are not critical and implementation of the south-to-north plan of service with additional 500 and

230 kV circuits makes single line 500 kV outages even less significant. Therefore, the analysis was conducted only for double contingencies, which may affect Path 15 transfer limits. These contingencies are:

- Los Banos – Gates and Los Banos – Midway (Los Banos South) double line outage,
- Midway – Gates and Midway Los Banos (Midway North) double line outage,
- PDCI bipole outage[3],
- Palo Verde double unit outage.

In this study, Midway - Vincent double line outages were not simulated assuming that Path 26 transfer capability remains unchanged (about 3000 MW) or increases to 4000 MW due to additional remedial actions, which are not in the scope of this study.

A series of calculations was conducted for each outage to reveal Path 15 limitations. An increase of Path 15 flow, produced in the calculations, was accompanied by generation decrease in the ZP26 area. The goal of this rescheduling was to prevent exceeding the assumed 3000 or 4000 MW limit on Path 26.

Remedial actions for each of the contingencies were implemented in accordance with the California Operating Studies Subcommittee (OSS) Handbook. The total MW values of remedial actions for all outages investigated in this study are:

| | Outage | Remedial action | Value (MW) | Status |
|---|---|---|---|---|
| 1 | LB-Gates & LB-Mdw | N.Calif. Gen. Drop | 1,080 | Existing |
| | | Mdw Area Pump Drop | 240 | Existing |
| 2 | LB-Mdw & Gates-Mdw | N.Calif. Gen. Drop | 1080 | Recommended |
| | | Midway Area Pump Drop | 240 | Existing |
| 3 | PDCI bi-pole | Northwest, Gen. Drop | 2,600-2700 | Existing |
| 4 | Palo Verde double unit outage | | | |

Remedial actions for outages 1 and 2 also include bypass of series capacitors on Table Mountain – Tesla, Table Mountain – Vaca Dixon and Olinda – Maxwell 500 kV lines.

Insertion of series capacitors at Fort Rock and shunt capacitors at Malin and Olinda was executed in dynamic simulations if a considering outage results in the operation of the Northwest Fast AC Reactive Insertion (FACRI) Remedial Action Scheme. The dynamic FACRI model executes these actions automatically depending on an outage and voltage at the Malin 500 kV bus.

[3] This outage was treated with single outage planning criteria because of the frequency of bipole outages.

The following factors were considered in defining equipment ratings for the conditions simulated in this study.

- Post-contingency loadings for all Path 15 and Path 26 500 kV facilities are not critical in this study because the flow currents do not exceed 3000A. This is much less than the 3560 A 30-min. summer emergency ratings, proposed for PG&E-owned facilities in a recent PG&E study.

- The Gates – Arco and Gates – Midway 230 kV lines are strung with 795 ACSR conductors. A 1070 A short-term rating[4] will be used assuming the following conditions:
  - initial line current of about 300 A,
  - maximum current of 1070 A for 15 minutes,
  - followed by system re-dispatch to reduce current flow to 750 A (normal rating) over the next 15-minutes
  - ambient temperature of $43^0$C ($110^0$F),
  - wind speed of 2 feet per second,
  - conductor temperature does not exceed $100^0$C,

The Gates-Panoche 230 kV lines are also strung with 795 ACSR conductor and the 1070 A rating will be used.

# 4. CONTINGENCY ANALYSIS

## *4-1. Los Banos South double line outage. Post-transient analysis. (Table 4-1)*

*Pre-project conditions*

The analysis for pre-project conditions was started (simulation 1) from 1280 MW[5] on Path 15 and with 4000 MW on Path 26. Even without remedial actions, the post-contingency loading of Gates-Panoche 230 kV line (870 A) is far from critical.

With Path 15 flow increased to 2130 MW (simulation 2), this double line outage results in 1015 A on the Gates-Panoche 230 kV lines (quite close to 1070 A limit). This simulation features execution of presently available remedial actions, including a trip of more than 1000 MW of hydro generators (Hyatt, Thermalito, Caribou) and more than 200 MW of CDWR pump load in the Midway/Vincent area.

[4] This is conservative rating because PG&E has established 230 kV facilities re-ratings to accommodate 30-min. operating procedures for south-to-north conditions with a reduced 10 minute maximum current time. Such procedures may increase ratings by about 45 amps.

[5] This was critical flow in the earlier studies for reactive margin conditions on Palo Verde DLO, which was based on 4600-4800 MW on COI. Note that this study models lower flow on COI, enabling higher flows on Path 15.

This limitation ($2130^+$ MW) does not practically depend on flow on Path 26 and the magnitude of generation at DCPP and Midway area because it is caused by an upstream component of Path 15, impacted by the outage.

It should be also noted that Simulation 2 with 3955 MW on Path 26 features significant generation in ZP26,. This makes possible 1000 MW of further generation reduction in the Midway area combined with a reduction Path 26 flow to its present 3000 MW rating. Therefore $2130^+$ MW on Path 15 is achievable even with the 3000 MW Path 26 rating. Simulation 3 illustrates that the Los Banos South DLO provides acceptable system performance for transfer of 2130 MW on Path 15 if Path 26 flow is limited to 3000 MW. However, a final decision about Path 15 limits can be made only after consideration of all outages.

*Post-project conditions*

With the third 500 kV Path 15 line, a Los Banos South double line outage becomes less critical. Simulation 4 shows the increase of initial Path 15 flow to 3265 MW, which was achieved with generation reduction in the Midway area to keep 4000 MW on Path 26. This increase to 3265 MW does not cause post-contingency overloads of the new Los Banos – Gates 500 kV line and Gates-Panoche 230 kV lines. Further flow increase on Path 15 (unless it is accompanied with taking one of the two DCPP units off-line) would overload Path 26 because this cannot be implemented with generation reduction in the Midway area. The only remaining generating unit in the Midway area is Morro Bay (200 MW), which cannot be taken out of service because it is required for the backup of DCPP auxiliary load.

Path 15 flow was modeled at 3885 MW in Simulation 5 with one DCPP unit on-line. In this case, a Los Banos South double line outage was simulated without remedial actions and did not cause any violations.

Simulation 6 also features one DCPP unit, 4385 MW on Path 15 and a Los Banos South double line outage with implementation of remedial actions. In this case with one DCPP unit, Midway area generation cannot be reduced anymore as in Simulation 3. Therefore conditions of Path 26 limit Path 15 flow in the post-project scheme to 4385 MW. However, the next section considers more critical Path 15 limitations related to the Midway North DLO.

### 4-2. 4-2. *Midway North double line outage Post-transient analysis. (Table 4-2)*

*Pre-project conditions*

In simulations 1 and 2, the Gates – Arco 230 kV line experiences a post-transient current increase to about 850 A. The same 850 A value was achieved in these simulations even though there were different initial flows on Path 15 (1750 MW in Simulation 1 and 1555 MW in Simulation 2) and on Path 26 (3985 MW in Simulation 1 and 2955 MW in Simulation 2), and different levels of generation in the Midway area (1700 MW in Simulation 1 and 925 MW in Simulation 2). This phenomenon can be explained by examining the route of power flow in these post-transient simulations from the Midway area generators to Path 26. The power is injected at the Midway 230 kV bus and flows to Path 26 via the 500/230 kV Midway transformer and displaces some of Gates – Arco – Midway flow to 500 kV route via DCPP. The higher level of Midway area generation in Simulation 1 displaced more Gates - Arco flow than in Simulation 2 allowing an additional 200 MW of initial flow on Path 15 in Simulation 1.

Simulation 3 shows that DCPP operation with one unit provides the same 850 A post-transient current on Gates – Arco 230 kV line with Path 15 flow increased by about 300 MW to 2070 MW. This increase is possible because the absence of one DCPP unit unloads not only the DCPP – Midway 500 kV lines but also the Midway – Gates 500 kV line and the Gates – Arco 230 kV line. However, this does not necessarily result in an increased pre-project Path 15 limit because of the 2130 MW limitation for a Los Banos South outage. It should be noted that reduction of the Midway area generation does not reduce Gates – Arco 230 kV line flows and actually has the opposite effect as follows from simulations 1 and 2.

Simulation 4 does verify that a Path 15 flow of 2130 MW, allowable for a Los Banos South DLO, is acceptable for a Midway North DLO. This is true with the 1070 MW of the Gates – Arco line rating which corresponds to application of the 30-min. (15+15) operating procedure.

Simulation 3 shows that with given initial flow on Path 15, operation with one DCPP unit positively affects post-transient Path 15 conditions. At the same time, operation with one DCPP unit provides a more than 1000 MW flow reduction on Path 26. Therefore, the 2130 MW Path 15 limit is certainly valid with the 3000 MW Path 26 rating if DCPP operates with one unit. It is not valid with two DCPP units and if 3000 MW flow on Path 26 is achieved by an additional reduction of Midway area generation. The Path 15 limit in this case is 1935 MW as follows from Simulation 1 and 2 and simulation 5, featuring Midway North DLO in the case with 3000 MW on Path 26.

*Post-project conditions*

Simulations 6 shows that new Gates – Midway 230 kV line experiences a post-transient current increase to 850 A if Path 15 flow is about 2150 MW.

Simulation 7 shows that an automatic trip of 1050 MW of hydro generators in northern California could reduce post-transient Path 15 flow and would allow increase a Path 15 limit by about 2710-2150=560 MW[6]. This is the same trip that is currently used on a Los Banos South double line outage and it should be quite easy to implement this trip for a Midway North.

[6] 2710 MW is not a critical flow because post-transient Gates-Midway 230 kV line current is only 845 A.

Simulation 8 also features additional trip of 1050 MW and shows that Path 15 can be loaded to 3265 MW without exceeding the 1070 MW of the Gates – Arco 15-min. line rating.

Simulation 9 demonstrates transferring 3375 MW on Path 15 with a rated Path 26 flow of 3000 MW. This is possible if one DCPP unit is out of service in addition to reduced to 200 MW Midway area generation.

Simulation 10 shows that Path 15 loading should be reduced by 1000 MW if Path 26 limit is 3000 MW and DCPP operates with two units.

Table 4-1
Double outage Los Banos – Gates and Los Banos – Midway
Post-transient analysis

| | Base case | Case adjustments | | | | Path flows (MW) | | | | DCPP | Morro, Sunset | Reactive margin (MVAR) | | | | | | Voltage | Loading of critical component (A) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Code | RAS values | | Aditional | Path | Path | COI | Bor-W | gener | & new Mdw. | LBns | Gates | Mdw | Pan | Malin | Gates | deviation | | | |
| | | | GT(MW) | LT(MW) | RAS | 15 | 26 | 66 | 17 | | generators | 500 | 500 | 500 | 230 | 500 | 230 | >10% | Element | Limit | Load |
| 1 | Pre-Project | Initial | | | | 1280 | 3960 | 4280 | 695 | 2270 | 2150 | | | | | | | | | | |
| | | Post-transient | - | - | - | 855 | 3595 | 3975 | 475 | | | | | | | | | | Pan-Gts | 1070 | 870 |
| 2 | Pre-Project | Initial | | | | 2130 | 3955 | 4230 | 650 | 2270 | 1300 | | | | | | | | | | |
| | | Post-transient | 1080 | 240 | Bps sr caps | 1035 | 3175 | 4180 | 425 | | | 2040 | 2010 | 2310 | 1325 | 1560 | 1620 | | Pan-Gts | 1070 | 1015 |
| 3 | Pre-Project | Initial | | | | 2125 | 2990 | 4290 | 696 | 2270 | 300 | | | | | | | | | | |
| | | Post-transient | 1080 | 240 | Bps sr caps | 1052 | 2225 | 4260 | 470 | | | | | 2200 | | 1420 | | | Pan-Gts | 1070 | 1035 |
| 4 | Post-Project | Initial | | | | 3265 | 3980 | 4240 | 600 | 2270 | 200 | | | | | | | | | | |
| | | Post-transient | | | | 2960 | 3705 | 4020 | 435 | | | 2070 | 1440 | 1525 | 1345 | 2260 | 1235 | | Pan-Gts<br>LB-Gts | 1070<br>4000 | 816<br>2427 |
| 5 | Post-Project | Initial | | | | 3885 | 3950 | 4245 | 565 | 1135 | 685 | | | | | | | | | | |
| | | Post-transient | | | | 3495 | 3595 | 3970 | 360 | | | 1285 | 875 | 1010 | 880 | 2035 | 755 | | Pan-Gts<br>LB-Gts | 1070<br>4000 | 973<br>2950 |
| 6 | Post-Project | Initial | | | | 4385 | 3950 | 4230 | 535 | 1135 | 200 | | | | | | | | | | |
| | | Post-transient | 1080 | 240 | Bps sr caps | 3350 | 3205 | 4295 | 375 | | | | | | | | | | Pan-Gts<br>LB-Gts | 1070<br>4000 | 930<br>2780 |

Table 4-2
Double outage Midway – Los Banos and Midway – Gates.
Post-transient analysis

| | Base case | Case adjustments | | | | Path flows (MW) | | | | DCPP gener | Morro, Sunset & new Mdw. gener | Reactive margin (MVAR) | | | Voltage deviation >10% | Loading of critical component (A) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Code | RAS values | | Aditional RAS | Path 15 | Path 26 | COI 66 | Bor-W 17 | | | Malin 500 | Arco 230 | DCPP 500 | | Element | Limit | Load |
| | | | GT(MW) | LT(MW) | | | | | | | | | | | | | | |
| 1 | Pre-Project | Initial | | | | 1750 | 3985 | 4260 | 670 | 2270 | 1700 | | | | | | | |
| | | Post-trans | | 216 | | 1390 | 3820 | 3949 | 490 | | | | | | | Gts-Arco | | 855 |
| 2 | Pre-Project | Initial | | | | 1555 | 2955 | 4280 | 725 | 2200 | 925 | | | | | | | |
| | | Post-trans | | 216 | | 1230 | 2830 | 3995 | 575 | | | | | | | Gts-Arco | | 845 |
| 3 | Pre-Project | Initial | | | | 2070 | 2915 | 4245 | 705 | 1100 | 1460 | | | | | | | |
| | | Post-trans | | 216 | | 1230 | 2830 | 3995 | 575 | | | 2930 | 970 | 1850 | | Gts-Arco | | 850 |
| 4 | Pre-Project | Initial | | | | 2130 | 3955 | 4230 | 650 | 2270 | 1300 | | | | | | | |
| | | Post-trans | | 216 | | 1735 | 3740 | 3875 | 445 | | | | | | | Gts-Arco | 1070* | 1067 |
| 5 | Pre-Project | Initial | | | | 1935 | 3000 | 4300 | 700 | 2270 | 500 | | | | | | | |
| | | Post-trans | | 216 | | 1575 | 2830 | 3985 | 520 | | | | | | | Gts-Arco | 1070* | 1065 |
| 6 | Post-Project | Initial | | | | 2150 | 3980 | 4260 | 645 | 2270 | 1300 | | | | | | | |
| | | Post-trans | | 216 | | 1765 | 3765 | 3915 | 445 | | | | | | | Gts-Mdw<br>Gts-Arco | | 840<br>800 |
| 7 | Post-Project | Initial | | | | 2710 | 3985 | 4260 | 630 | 2270 | 745 | | | | | | | |
| | | Post-trans | 1050 | 216 | | 1930 | 3415 | 4400 | 540 | | | 1920 | 700 | 1500 | | Gts-Mdw<br>Gts-Arco | | 845<br>800 |
| 8 | Post-Project | Initial | | | | 3265 | 3980 | 4240 | 600 | 2270 | 200 | | 580 | | | | | |
| | | Post-trans | 1050 | 216 | | 2445 | 3350 | 4345 | 470 | | | | | | | Gts-Mdw | 1070* | 1050 |
| 9 | Post-Project | Initial | | | | 3375 | 2980 | 4300 | 655 | 1130 | 200 | | | | | | | |
| | | Post-trans | 1050 | 216 | | 2590 | 2390 | 4440 | 545 | | | | | | | Gts-Mdw | 1070* | 960 |
| | | | | | | | | | | | | | | | | Gts-Arco | 1070* | 900 |
| 10 | Post-Project | Initial | | | | 2265 | 3000 | 4330 | 695 | 2270 | 200 | | | | | | | |
| | | Post-trans | 1050 | 216 | | 1560 | 2520 | 4540 | 640 | | | | | | | Gts-Mdw | 1070* | 715 |
| | | | | | | | | | | | | | | | | Gts-Arco | 1070* | 705 |

* - 1070 A is a 30-min. limit for 300 A and 1055 A is a 30-min. limit for 450 A of initial

### *4-3. Bi-pole loss of PDCI and Palo Verde double unit outages. Post-transient analysis. (Table 4-3)*

The simulations were conducted for system conditions with 2130 MW on Path15 in the pre-project scheme and 3250 MW on Path 15 in the post-project scheme. Those conditions were found critical regarding the double line outages considered in the previous sections

The simulations have shown that post-transient conditions (including reactive margins) after bi-pole loss of PDCI and Palo Verde double unit outages are far from critical and increase of flows to 2130/3250 MW would not lead to any violations. This result is opposite to the earlier studies because of the reduced COI flow and the addition of the new power plants provides better voltage support. For Palo Verde DLO, this result was confirmed in the simulations with and without insertion of series capacitors at Fort Rock and shunt capacitors at Malin and Olinda. Transient voltage dips in the Northern part of the PG&E area might be insufficient to initiate this action if Palo Verde units trip subsequently.

Therefore bi-pole loss of PDCI and Palo Verde double unit outages do not change Path 15 limitations, determined by the Los Banos South and Midway North double line outages.

### *4-4. Transient analysis*

Figures 1-17 in Appendix 1 present the results of dynamic (transient) stability calculations for the studied contingencies.

Eight simulations were conducted for the four outages in the pre-project scheme with 1750 MW on Path15 and in the post-project scheme with 2710 MW on Path 15.

The study results are presented by the pairs of plots showing a change of generator rotor angles and bus voltages over time (1 second of initial steady state conditions before a contingency plus 14 seconds of transient changes). The Pittsburg power plant generator is used for the angle reference.

Dynamic simulations, conducted with 1750 MW on Path 15 in the pre-project scheme and 2710 MW on Path 15 in the post-project scheme, did not show significant angular swings or voltage dips. The most intensive swings ware indicated for Palo Verde DLO. This was the reason for the ninth simulation with 3265 MW on Path 15. This simulation also did not reveal any violation.

All simulations included modeling of remedial actions, specified for each outage in accordance with OSS Handbook of recommendations of this study based on the post-transient analysis.

Table 4-3
Palo Verde Double Unit & PDCI bi-pole outages
Post-transient analysis

| | Base | Outage | Case adjustments | | | | Path flows (MW) | | | | DCPP | Morro, Sunset | Reactive margin (MVAR) | | | | Voltage | Loading of critical | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | case | | Code | RAS values | | Aditional | Path | Path | COI | Bor-W | gener | & new Mdw. | Malin | Mdw | Vinc | Devers | deviation | component (A) | | |
| | | | | GT(MW) | LT(MW) | RAS | 15 | 26 | 66 | 17 | | generators | 500 | 500 | 500 | 500 | >10% | Element | Limit | Load |
| | Pre- | Palo Verde | Initial | | | | 2130 | 3955 | 4205 | 665 | 2270 | 1300 | | | | | | | | |
| 1 | Project | DUO | Post-trans | | | | 3340 | 5205 | 5130 | 560 | | | 690 | 1970 | | 1550 | | | | |
| | | | Post-trans | | | Insrt sr.& | 3405 | 5270 | 5180 | 560 | | | 1475 | | | | | | | |
| | | | | | | sht caps | | | | | | | | | | | | | | |
| | Post- | Palo Verde | Initial | | | | 3250 | 3960 | 4145 | 615 | 2270 | 200 | | | | | | | | |
| 2 | Project | DUO | Post-trans | | | | 4360 | 5085 | 5115 | 515 | | | 435 | 1200 | 1430 | 1480 | | | | |
| | | | Post-trans | | | Insrt sr.& | 4430 | 5160 | 5170 | 515 | | | 1195 | | | | | | | |
| | | | | | | sht caps | | | | | | | | | | | | | | |
| | Pre- | PDCI | Initial | | | | 2130 | 3955 | 4205 | 665 | 2270 | 1300 | | | | | | | | |
| 3 | Project | bi-pole | Post-trans | 2660 | | Insrt sr.& | 3595 | 5435 | 5655 | 515 | | | 1585 | | | | | | | |
| | | | | | | sht caps | | | | | | | | | | | | | | |
| | Post- | PDCI | Initial | | | | 3265 | 3980 | 4260 | 600 | 2270 | 200 | | | | | | | | |
| 4 | Project | bi-pole | Post-trans | 2660 | | Insrt sr.& | 4650 | 5360 | 5565 | 515 | | | 1250 | 1165 | 1390 | 1445 | | | | |
| | | | | | | sht caps | | | | | | | | | | | | | | |

## 5. ADDITIIONAL STUDY WORK

Initial system conditions of this study were designed with the purpose to reveal maximum possible Path 15 transfer capability, which corresponds to path rating. These features of system conditions are determined by the following:

a. The study was conducted for the moderate flow conditions in the rest of the system (primarily COI). The only exclusion is adjacent Path 26, which is fully loaded in many simulations because flow on Path 15 constitutes a significant part of flow on Path 26.
b. Flow on Path 15 was given highest priority in utilization of Path 26 transfer capability among other sources feeding Path 26.

Finding Path 15 north-to-south transfer capabilities with higher flows on COI will be in the scope of the additional study work. The main focus of this additional work will be on the system-wide outages such as Palo Verde DUO and PDCI DLO with different combinations of flow levels on COI and Path 15.

## 6. CONCLUSIONS

1. The Path 15 plan of service supports increased south-to-north Path 15 transfers. This same plan of service would be beneficial for increased north-to-south Path 15 flows. Such flows may occur in partial peak spring and summer conditions with a surplus of hydro generation resources in Northwest and Northern California and reduced generation in the Midway area.

2. The maximum Path 15 pre-project rating is about 2130 MW and is possible with the existing and proposed Path 26 ratings of 3000 MW and 4000 MW, respectively. The Path 15 rating was determined by a possible post-transient thermal overload of Gates – Panoche and Gates – Arco 230 kV lines. Actual simultaneous operating limits with higher COI flow might be lower than 2130 MW. Previous operating studies have shown that such conditions could result in a limit of 1280 MW.

3. The pre-project Path 15 rating would be reduced to about 1930 MW if the Midway area operates with reduced generation and with rated Path 26 flow of 3000 MW.

4. The maximum Path 15 post-project rating is 3265 MW and is possible with the existing and proposed Path 26 ratings of 3000 MW and 4000 MW, respectively.

However, the maximum benefits of Path 15 Upgrade for north-to-south flows can be achieved if the Path 26 rating is increased from 3000 to up to 4000 MW. This would allow greater flows on Path 15 without significant generation reduction in the Midway area.

5 Path 15 flow in the post-project scheme is limited primarily by the Midway North DLO causing overload of the Gates – Midway 230 kV line. Loadings on this line are maintained within its acceptable rating with an automatic trip of 1050 MW of hydro generators in northern California (in addition to the presently used 200 MW of pump load trip) and a 30-min. operating procedure. This 1050 MW trip is currently used for the Los Banos South DLO and would be easily implemented for a Midway North DLO. This generation trip will not be necessary for Los Banos South DLO following implementation of the Path 15 Upgrade.

6 DCPP operation with one unit cannot increase pre-project Path 15 transfer capability above the 2130 MW level because one of the limitations is overload of the Gates-Panoche 230 kV lines.

7 DCPP operation with one unit in post-project scheme unloads the critical Gates – Midway 230 kV line. This allows an increase of Path 15 transfer by about 100 MW with 3000 MW of Path 26 rating and about 300 MW with 4000 MW of Path 26 rating.